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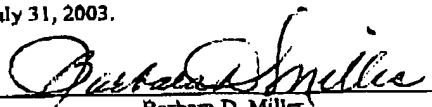
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By:

  
Barbara D. Miller

**ABSORBENT COMPOSITES ADAPTED TO PROVIDE IMPROVED  
PERMEABILITY**

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**BACKGROUND**

The present invention relates to absorbent composites having an improved intake of liquids. More particularly, the present invention relates to absorbent composites adapted to provide improved permeability.

Absorbent structures are significant in a broad range of disposable absorbent articles including infant diapers, child training pants, adult incontinence products, feminine hygiene products, and the like. These and other disposable absorbent articles are generally provided with an absorbent core to receive and retain body fluids. The absorbent core is usually sandwiched between a fluid pervious topsheet, whose function is to allow the passage of fluid to the core, and a liquid impervious backsheet, whose function is to contain liquid and prevent it from passing through the disposable absorbent article to the garment of the wearer of the disposable absorbent article.

An absorbent core for these disposable absorbent articles frequently includes fibrous batts or webs constructed of fiberized, loose, fluffed hydrophilic, cellulosic fibers. Such

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However, their ability to do so is somewhat limited. Thus superabsorbent materials, capable of absorbing many times their weight of liquid, are often included in the absorbent core to increase the absorbent capacity of the absorbent core, without having to substantially increase the bulkiness of the absorbent core.

5 Absorbent cores containing superabsorbent material have been successful, and in recent years, market demand has increased for thinner, more absorbent and more comfortable disposable absorbent articles. One approach to obtaining such a disposable absorbent article is to increase the proportion of superabsorbent material in relation to the other materials of the absorbent core. There are, however, practical limits to increasing the proportion of  
10 superabsorbent particles in the absorbent core. If the concentration of superabsorbent material is too high, for example, gel blocking can occur. When particles of superabsorbent material distributed through an absorbent core are exposed to liquid they swell as they absorb the liquid, forming a gel. As adjacent particles of superabsorbent material swell, they form a barrier to free liquid not immediately absorbed by the particles of superabsorbent material.  
15 As a result, access by the liquid to unexposed particles of superabsorbent material may be blocked by the swollen (gelled) particles of superabsorbent material. When gel blocking occurs, liquid pooling, as opposed to absorption, takes place in the absorbent core. As a result, large portions of the absorbent core remain unused, and failure – typically in the form of leakage – of the absorbent core can occur. Gel blocking caused by high concentrations of  
20 particles of superabsorbent material results in reduced permeability (fluid intake) of the absorbent core under pressures normally encountered during use of the disposable absorbent article. As a result, there has remained a need to provide improved materials for use in disposable absorbent articles having a relatively high concentration (e.g., greater than 50 %, by weight) of superabsorbent material in their absorbent cores.

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#### SUMMARY

In response to the foregoing need, the present inventors undertook research and development efforts that resulted in the discovery of unique absorbent composites suitable for incorporation into the absorbent core of a variety of disposable absorbent articles.  
30 Specifically, the present inventors discovered a unique absorbent composite adapted to provide an improved permeability. One version of the present invention includes an absorbent composite having at least one particle of a superabsorbent material covered with a coating. The coating includes hydrophilic and silicate particles. Specifically, the absorbent composite of this version has a Free Swell Gel Bed Permeability of at least  $40 \times 10^{-8} \text{ cm}^2$ .  
35 Another version of the present invention includes an absorbent composite having at least one particle of a superabsorbent material covered with a coating. The coating includes hydrophilic and silicate particles. Specifically, the absorbent composite of this version has a

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Gel Bed Permeability Under Load of at least  $20 \times 10^{-8} \text{ cm}^2$ . Still another version of the present invention provides for a disposable absorbent article having a fluid pervious topsheet, a liquid impervious backsheet and an absorbent core disposed intermediate the topsheet and the backsheet. The absorbent core of the absorbent article includes an absorbent composite.

- 5 The absorbent composite includes at least one particle of a superabsorbent material covered with a coating of hydrophilic and silicate materials. The absorbent composite of this version have a Free Swell Gel Bed Permeability of at least  $40 \times 10^{-8} \text{ cm}^2$  and a Centrifuge Retention Capacity of no less than 20 g/g.

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### DRAWINGS

The foregoing and other features and aspects of the present invention and the manner of attaining them will become more apparent, and the invention itself will be better understood by reference to the following description, appended claims and accompanying drawings, where:

- 15 FIG. 1 illustrates a representative fluidized bed coating apparatus;  
FIG. 2 illustrates a cross-section of a representative apparatus for conducting a Gel Bed Permeability Test;  
FIG. 3 is a section taken in the plane of line 3-3 of FIG. 2;  
FIG. 4 is a cross-section of a representative apparatus for conducting an Absorbency  
20 Under Load Test; and  
FIG. 5 is a section taken in the plane of line 5-5 of FIG. 4.

### DESCRIPTION

- 25 The absorbent composites of the present invention include at least one particle of superabsorbent material covered with a coating of hydrophilic and silicate particles.

- By "particle," "particles," "particulate," "particulates" and the like, it is meant that a material is generally in the form of discrete units. The particles can include granules, pulverulents, powders or spheres. Thus, the particles can have any desired shape such as, for example, cubic, rod-like, polyhedral, spherical or semi-spherical, rounded or semi-rounded,  
30 angular, irregular, *etc.* Shapes having a large greatest dimension/smallest dimension ratio, like needles, flakes and fibers, are also contemplated for use herein. The use of "particle" or "particulate" may also describe an agglomeration including more than one particle, particulate or the like.

- As used herein, the phrase "intimate association" and other similar terms are intended  
35 to encompass configurations including the following: those where at least a portion of the surface of at least one particle of a coating material is in contact with a portion of the surface of at least one particle of superabsorbent material; and/or those where at least a portion of the

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surface of at least one particle of a coating material is in contact with a portion of the surface of at least one other particle of a coating material.

As used herein, "superabsorbent material," "superabsorbent materials" and the like are intended to refer to a water-swellable, water-insoluble organic or inorganic material capable, under the most favorable conditions, of absorbing at least about 10 times its weight and, desirably, at least about 15 times its weight in an aqueous solution containing 0.9 weight percent of sodium chloride. Such materials include, but are not limited to, hydrogel-forming polymers which are alkali metal salts of: poly(acrylic acid); poly(methacrylic acid); copolymers of acrylic and methacrylic acid with acrylamide, vinyl alcohol, acrylic esters, vinyl pyrrolidone, vinyl sulfonic acids, vinyl acetate, vinyl morpholinone and vinyl ethers; hydrolyzed acrylonitrile grafted starch; acrylic acid grafted starch; maleic anhydride copolymers with ethylene, isobutylene, styrene, and vinyl ethers; polysaccharides such as carboxymethyl starch, carboxymethyl cellulose, methyl cellulose, and hydroxypropyl cellulose; poly(acrylamides); poly(vinyl pyrrolidone); poly(vinyl morpholinone); poly(vinyl pyridine); and copolymers and mixtures of any of the above and the like. The hydrogel-forming polymers are preferably lightly cross-linked to render them substantially water-insoluble. Cross-linking may be achieved by irradiation or by covalent, ionic, van der Waals attractions, or hydrogen bonding interactions, for example. A desirable superabsorbent material is a lightly cross-linked hydrocolloid. Specifically, a more desirable superabsorbent material is a partially neutralized polyacrylate salt.

Superabsorbent materials employed in the present invention suitably should be able to absorb a liquid under an applied load. For purposes of this application, the ability of a superabsorbent material to absorb a liquid under an applied load and thereby perform work is quantified as the Absorbency Under Load (AUL) value. The AUL value is expressed as the amount (in grams) of an approximately 0.9 weight percent saline (sodium chloride) solution absorbed by about 0.160 grams of superabsorbent material when the superabsorbent material is under a load. Common loads, further described hereinbelow, include those of approximately 0.01; 0.3; 0.6; and 0.9 pound per square inch (psi). Superabsorbent materials suitable for use herein desirably have an AUL value (under a load of approximately 0.3 psi) of at least 7; alternatively, at least 9; alternatively, at least 15; alternatively, at least 20; alternatively, at least 24; and, finally, alternatively, at least about 27 g/g. Superabsorbent materials useful in the present invention are generally available from various commercial vendors, such as, for example, Dow Chemical Company or Stockhausen, Inc.

The method by which AUL is determined is set forth in greater detail below. The AUL is thought to be a function of the following factors: (1) gel stiffness while swelling, (2) ability to imbibe the fluid by osmotic and internal electrostatic repulsion forces, (3) surface wettability of the superabsorbent material and (4) particle size distribution when wet.

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Suitably, the superabsorbent material is in the form of particles which, in the unswollen state, have maximum diameters ranging between about 50 and about 1,000 microns; desirably, between about 100 and about 800 microns; more desirably, between about 200 and about 650 microns; and most desirably, between about 300 and about 600 microns, as determined by sieve analysis according to American Society for Testing Materials Test Method D-1921. It is understood that the particles of superabsorbent material may include solid particles, porous particles, or may be agglomerated particles including many smaller particles agglomerated into particles falling within the described size ranges.

The absorbent composites of the present invention also include a coating of hydrophilic and silicate particles. In such an instance, the coating is in intimate association with and covering the superabsorbent material. A wide variety of natural and synthetic materials can be employed in the coating of the present invention. Materials suitable for incorporation into the coating therefore include adsorbent and/or absorbent material. It is, of course, desired to use materials that are inexpensive, readily available and safe - important attributes for a material used in the disposable absorbent articles described herein. Illustrative examples of material suitable for use in the coating of the present invention include particles of hydrophilic material. Examples of suitable hydrophilic material include, but are not limited to, cellulosic materials, both natural and synthetic, such as wood pulp and products made from it such as powdered cellulose, and non-woody cellulose materials such as cotton, linen, jute, abaca, ixtl and the like, and products made from them such as cotton linters and floc; regenerated cellulose such as rayon, cupram, lyocell and the like; and cellulose derivatives such as hydroxypropyl cellulose, hydroxyethyl cellulose, ethyl cellulose, cellulose acetate and the like. A particularly desired hydrophilic material is microcrystalline cellulose powder.

In general, hydrophilic materials suitable for use in the present invention are typically in the form of fibers having a length of no less than 50; alternatively, no less than 60; alternatively, no less than 70; alternatively, no less than 75; alternatively, no less than 80; alternatively, no less than 90; alternatively, no less than 100; alternatively, no less than 110; alternatively, no less than 120; alternatively, no less than 125; alternatively, no less than 130; alternatively, no less than 135; alternatively, no less than 140; alternatively, no less than 145; alternatively, no less than 150; alternatively, no less than 155; alternatively, no less than 160; alternatively, no less than 170; alternatively, no less than 175; alternatively, no less than 180; alternatively, no less than 190; alternatively, no less than 200; alternatively, no less than 225; alternatively, no less than 245; alternatively, no less than 250; alternatively, no less than 255; alternatively, no less than 275; alternatively, no less than 300; alternatively, no less than 325; alternatively, no less than 350; alternatively, no less than 375; alternatively, no less than 400; alternatively, no less than 450; alternatively, no less than 500; alternatively, no less than 550;

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alternatively, no less than 600; alternatively, no less than 650; alternatively, no less than 700; alternatively, no less than 750; alternatively, no less than 800; or finally, alternatively, no less than 850 microns. In addition, fibers of hydrophilic materials suitable for use in the present invention typically have a length of no more than 900; alternatively, no more than 875; 5 alternatively, no more than 825; alternatively, no more than 775; alternatively, no more than 725; alternatively, no more than 675; alternatively, no more than 625; alternatively, no more than 575; alternatively, no more than 525; alternatively, no more than 475; alternatively, no more than 425; alternatively, no more than 400; alternatively, no more than 375; alternatively, no more than 350; alternatively, no more than 325; alternatively, no more than 300; 10 alternatively, no more than 275; alternatively, no more than 250; alternatively, no more than 225; alternatively, no more than 200; alternatively, no more than 175; alternatively, no more than 150; alternatively, no more than 125; alternatively, no more than 100; or finally, alternatively, no more than 75 microns. Thus, fibers of a suitable hydrophilic material may have a length ranging from no less than 50 microns up to no more than 900 microns; although 15 the approximate length of a particular fiber of a suitable hydrophilic material may vary according to, *inter alia*, the general design and intended use of the absorbent composite. In general, fibers of a suitable hydrophilic material may have diameters of no less than 5; alternatively, no less than 10; alternatively, no less than 15; alternatively, no less than 20; alternatively, no less than 25; alternatively, no less than 30; alternatively, no less than 35; 20 alternatively, no less than 40; alternatively, no less than 45; alternatively, no less than 50; alternatively, no less than 55; alternatively, no less than 60; alternatively, no less than 65; or finally, alternatively, no less than 70 microns. In addition, fibers of a suitable hydrophilic material may have diameters of no more than 75; alternatively, no more than 70; alternatively, no more than 65; alternatively, no more than 60; alternatively, no more than 55; alternatively, 25 no more than 50; alternatively, no more than 45; alternatively, no more than 40; alternatively, no more than 35; alternatively, no more than 30; alternatively, no more than 25; alternatively, no more than 20; alternatively, no more than 15; or finally, alternatively, no more than 10 microns. Thus, fibers of a suitable hydrophilic material may have a diameter ranging from no less than 5 microns up to no more than 75 microns; although the approximate diameter of a 30 particular fiber of a suitable hydrophilic material may vary according to, *inter alia*, the general design and intended use of the absorbent composite. In certain versions of the present invention, at least a portion of at least one particle of hydrophilic material extends outwardly from the surface of the absorbent composite.

Although hydrophilic materials have been indicated as being suitable for use in the 35 coating of the present invention, one skilled in the art would readily appreciate the possibility of treating the surfaces of hydrophobic materials by an appropriate known method to render the hydrophobic materials more or less hydrophilic. As previously indicated, materials

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suitable for incorporation into the coating are in particulate form; consequently, it is understood that the particles of a suitable coating material may include solid particles, porous particles, or may be an agglomeration of more than one particle.

Other materials suitable for incorporation into the coating of the present invention include silicates, both natural and synthetic, such as precipitated silica, fumed silica, silicon dioxide, zeolites, clays, vermiculite, perlite and the like. Typically, suitable silicates have a diameter of no less than 100; alternatively, no less than 150; alternatively, no less than 200; alternatively, no less than 225; alternatively, no less than 250; alternatively, no less than 275; alternatively, no less than 300; alternatively, no less than 325; alternatively, no less than 350; alternatively, no less than 375; alternatively, no less than 400; alternatively, no less than 425; alternatively, no less than 450; alternatively, no less than 475; alternatively, no less than 500; or finally, alternatively, no less than 550 microns. In addition, suitable silicates typically have a diameter of no more than 600; alternatively, no more than 550; alternatively, no more than 475; alternatively, no more than 450; alternatively, no more than 425; alternatively, no more than 400; alternatively, no more than 375; alternatively, no more than 350; alternatively, no more than 325; alternatively, no more than 300; alternatively, no more than 275; alternatively, no more than 250; alternatively, no more than 225; alternatively, no more than 200; alternatively, no more than 175; or finally, alternatively, no more than 125 microns. Thus, particles of a suitable silicate material may have a diameter ranging from no less than 100 microns up to no more than 600 microns; although the approximate diameter of a particular particle of a suitable silicate material may vary according to, *inter alia*, the general design and intended use of the absorbent composite.

Use of "cover," "covers," "covering" or "covered" with regard to materials suitable for use in the coating of the present invention is intended to indicate that the material(s) extend(s) over the surface of the material being covered to the extent necessary to realize many of the advantages of the present invention. Without desiring to be bound by theory, this includes situations where the coating extends over at least 20; alternatively, over at least 30; alternatively, over at least 40; alternatively, over at least 50; alternatively, over at least 60; alternatively, over at least 70; alternatively, over at least 80; and finally, alternatively, over at least 90 percent of the surface of the material being covered. The term "surface" and its plural generally refer herein to the outer or the topmost boundary of an object.

In various embodiments of the present invention, the intimate association of at least a portion of the material(s) coating a particle of superabsorbent material is achieved with the use of an association agent. The association agent usually includes substances that can be applied in liquid or semi-liquid form to either the superabsorbent material or the coating material(s). The term "applied" as used herein is intended to include situations where at least a portion of the surface of at least one particle of superabsorbent material has an



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effective amount of association agent on it to facilitate adherence, via mechanical and/or chemical bonding, of at least that portion of the surface of the superabsorbent material to a portion of the surface of at least one particle of a coating material; at least a portion of the surface of at least one particle of a coating material has an effective amount of association agent on it to facilitate adherence, via mechanical and/or chemical bonding, of at least that portion of the surface of a coating material to a portion of the surface of at least one particle of superabsorbent material; and/or at least a portion of the surface of at least one particle of a coating material has an effective amount of association agent on it to facilitate adherence, via mechanical and/or chemical bonding, of at least that portion of the surface of a coating material to a portion of the surface of at least one other particle of a coating material. Desirably, the association agent is applied to the selected material(s) in an amount no less than about 10; alternatively, no less than about 15; alternatively, no less than about 20; alternatively, no less than about 25; alternatively, no less than about 30; alternatively, no less than about 35; alternatively, no less than about 40; and finally, alternatively, no less than about 45 percent by weight. In addition, the association agent is applied to the selected material(s) in an amount no more than about 50; alternatively, no more than about 45; alternatively, no more than about 40; alternatively, no more than about 35; alternatively, no more than about 30; alternatively, no more than about 25; alternatively, no more than about 20; alternatively, no more than about 15; or finally, alternatively, no more than about 10 percent by weight. Thus, an effective amount of association agent may range from no less than about 10 percent by weight up to no more than about 50 percent by weight; although the amount of association agent effectively used may vary according to, *inter alia*, the general design and intended use of the absorbent composite.

The selection of a particular association agent can be made by one skilled in the art and will typically depend upon the chemical composition of the materials to be maintained in intimate association with one another. Desirably, the association agent is suitable for use in applications involving human contact. Thus, the association agent should be non-toxic and non-irritating to humans. An association agent suitable for use in the present invention is typically prepared by the formation of a liquid or semi-liquid capable of being generally uniformly atomized. In particular, a solution, dispersion or emulsion including at least one of the association agents identified herein may be prepared. Although the association agent is described herein as being applied as finely atomized droplets, it may be applied to the selected material by any other method such as by spraying in liquid or semi-liquid form, spraying and blowing in the form of steam, and the like.

Several types of association agent are capable of being employed in the present invention. Illustrative association agents suitable for use in various embodiments of the present invention include, for example: water; volatile organic solvents such as alcohols;

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aqueous solutions of film-forming materials such as dried milk, lactose, soluble soy protein, and casein; synthetic adhesives such as polyvinyl alcohol; and mixtures thereof. The presence of water in the association agent is particularly effective in predisposing the superabsorbent material to wetting.

5 As used herein, the phrase "absorbent article" refers to devices which absorb and contain body fluids, and more specifically, refers to devices which are placed against or near the skin to absorb and contain the various fluids discharged from the body. The term "disposable" is used herein to describe absorbent articles that are not intended to be laundered or otherwise restored or reused as an absorbent article after a single use. Examples of such  
10 disposable absorbent articles include, but are not limited to: health care related products including ostomy products, surgical drapes, gowns, and sterilization wraps; personal care absorbent products such as feminine hygiene products, diapers, training pants, incontinence products and the like; as well as facial tissues.

Disposable absorbent articles such as, for example, many of the personal care  
15 absorbent products, typically include a fluid pervious topsheet, a liquid impervious backsheet joined to the topsheet and an absorbent core positioned between the topsheet and the backsheet. Disposable absorbent articles and components thereof, including the topsheet, backsheet, absorbent core and any individual layers of these components, generally have a body-facing surface and a garment-facing surface. As used herein, "body-facing surface"  
20 refers to that surface of the article or component which is intended to be worn toward or placed adjacent to the body of the wearer, while the "garment-facing surface" is on the opposite side and is intended to be worn toward or placed adjacent to the wearer's garments when the disposable absorbent article is worn.

The absorbent composites of the present invention are suitable for use in a variety of  
25 disposable absorbent articles. In general, the absorbent composites may be used in a manner similar to that in which other absorbent composites have been used: for example, in laminates, in relatively high density cores (*i.e.*, compacted cores, calendered cores, densified cores, *etc.*), or in relatively low density cores (*i.e.*, not compacted, for example, air-laid cores). However, the absorbent composites of the present invention provide certain advantages over  
30 conventional absorbent composites. In particular, the absorbent composites of the present invention are adapted to demonstrate an improved efficacy in the intake of certain body fluids. More particularly, the superabsorbent-containing composites of the present invention demonstrate an improved efficacy in the handling of menses. As a result of this improved efficacy, disposable absorbent articles incorporating the absorbent composites of the present  
35 invention may have a relatively high concentration of superabsorbent materials in their absorbent cores.

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The absorbent composites of the present invention may be prepared in a manner similar to fluidized bed coating processes. In one such embodiment, an effective amount of hydrophilic and silicate particles (*i.e.*, coating material) and at least one particle of superabsorbent material are suspended in a fluidized bed coating apparatus that creates a strong upward current or stream of fluidizing gas, usually air, typically at an inlet temperature approximating that of room temperature. The strong upward current or stream of fluidizing gas moves both the coating material and the superabsorbent material upward until the coating material and the superabsorbent material pass out of the upward stream and pass downward in a fluidized condition countercurrent to the upward stream of fluidizing gas. The coating material and the superabsorbent material may re-enter the upward-moving stream of fluidizing gas. While in the upward-moving stream, the coating material and the superabsorbent material pass through a zone where an association agent is applied to both the coating material and superabsorbent material. After the association agent is applied, the strong upward-moving stream of fluidizing gas, usually air, optionally at an elevated inlet temperature, moves the coating material and the superabsorbent material upward until the coating material and the superabsorbent material pass out of the upward stream and pass downward in a fluidized condition countercurrent to the upward stream of fluidizing gas. The coating material and the superabsorbent material may re-enter the upward-moving stream of fluidizing gas until an absorbent composite is formed. It is typically after the association agent is applied that at least a portion of the coating material comes into intimate association with the superabsorbent material to form an absorbent composite. The absorbent composite so formed is usually at least one particle of superabsorbent material covered with a coating of hydrophilic and silicate particles. At least a portion of the coating material is in intimate association with and covering the surface of the superabsorbent material.

It is desired that the absorbent composites of the present invention typically have no less than 65; alternatively, no less than 70; alternatively, no less than 75; alternatively, no less than 80; alternatively, no less than 85; alternatively, no less than 90; or finally, alternatively, no less than 95 percent superabsorbent, based on the weight of the superabsorbent material and the coating material in the absorbent composite. It is also desired that the absorbent composites of the present invention typically have no more than 98; alternatively, no more than 95; alternatively, no more than 90; alternatively, no more than 85; alternatively, no more than 80; alternatively, no more than 75; or finally, alternatively, no more than 70 percent superabsorbent, based on the weight of the superabsorbent material and the coating material in the absorbent composite. Thus, an absorbent composite of the present invention may include superabsorbent material in an amount ranging between no less than 65 weight percent up to no more than 98 weight percent; although the approximate weight percent of

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superabsorbent material may vary according to, *inter alia*, the general design and intended use of the absorbent composite.

It is further desired that the absorbent composites of the present invention typically have no less than 1; alternatively, no less than 5; alternatively, no less than 10; alternatively, no less than 15; alternatively, no less than 20; alternatively, no less than 25; or finally, alternatively, no less than 30 percent hydrophilic material, based on the weight of the superabsorbent material and the coating material in the absorbent composite. Moreover, the absorbent composites of the present invention typically have no more than 34; alternatively, no more than 30; alternatively, no more than 25; alternatively, no more than 20; alternatively, no more than 15; alternatively, no more than 10; or finally, alternatively, no more than 5 percent hydrophilic material, based on the weight of the superabsorbent material and the coating material in the absorbent composite. Thus, an absorbent composite of the present invention may include hydrophilic material in an amount ranging between no less than 1 weight percent up to no more than 34 weight percent; although the approximate weight percent of hydrophilic material may vary according to, *inter alia*, the general design and intended use of the absorbent composite.

In addition, it is desirable that the absorbent composites of the present invention typically have no less than 1; alternatively, no less than 5; alternatively, no less than 10; alternatively, no less than 15; alternatively, no less than 20; alternatively, no less than 25; or finally, alternatively, no less than 30 percent silicate material, based on the weight of the superabsorbent material and the coating material in the absorbent composite. Also, the absorbent composites of the present invention typically have no more than 34; alternatively, no more than 30; alternatively, no more than 25; alternatively, no more than 20; alternatively, no more than 15; alternatively, no more than 10; or finally, alternatively, no more than 5 percent silicate material, based on the weight of the superabsorbent material and the coating material in the absorbent composite. Thus, an absorbent composite of the present invention may include silicate material in an amount ranging between no less than 1 weight percent up to no more than 34 weight percent; although the approximate weight percent of silicate material may vary according to, *inter alia*, the general design and intended use of the absorbent composite.

Suitably, an absorbent composite of the present invention typically has a Centrifuge Retention Capacity (CRC) of no less than 15; alternatively, no less than 20; alternatively, no less than 25; or finally, alternatively, no less than 30 g/g. In addition, an absorbent composite of the present invention typically has a CRC of no more than 35; alternatively, no more than 30; alternatively, no more than 25; or finally, alternatively, no more than 20 g/g. Thus, an absorbent composite of the present invention may have a CRC ranging between no less than 15 g/g up to no more than 35 g/g; although the CRC of an absorbent composite of the present

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invention may vary according to, *inter alia*, the general design and intended use of the absorbent composite.

Typically, a fluidized bed coating apparatus similar to that illustrated in FIG. 1 can be utilized to form the absorbent composites of the present invention. Referring to FIG. 1, a generally vertically-mounted, generally cylindrical chamber (221) is open at a chamber proximal end (222) and closed at a chamber distal end (223). The chamber (221) is optionally provided with an inner chamber (224) that has a diameter less than that of the chamber (221). The inner chamber (224) is open at both an inner chamber proximal end (225) and an inner chamber distal end (226). The chamber proximal end (222) is fitted with a plate (227) that has a porous area (228) that generally matches the diameter of the inner chamber (224). The inner chamber (224) is positioned a distance above the plate (227) and is generally aligned along the vertical axis of the chamber (221). Through the porous area (228) is provided an upward current or stream (229) of fluidizing gas, usually air, typically at an inlet temperature approximating that of room temperature, such as from a valve (230) from a source of compressed gas (231). The upward-moving stream (229) of fluidizing gas generally flows through the inner chamber (224) by entering through the inner chamber proximal end (225) and exiting through the inner chamber distal end (226). At least one particle of a superabsorbent material (232) and an effective amount of hydrophilic and silicate particles (*i.e.*, the coating material (233)) are introduced into the chamber (221). The upward-moving stream (229) of fluidizing gas is adjusted so as to provide a fluid-like flow to both the superabsorbent material (232) and the coating material (233). The upward-moving stream (229) of gas moves the superabsorbent material (232) and the coating material (233) upward until the superabsorbent material and the coating material pass out of the upward stream and pass downward in a fluidized condition countercurrent to the upward-moving stream of fluidizing gas. The superabsorbent material (232) and the coating material (233) may re-enter the upward-moving stream (229) of fluidizing gas. While in the upward-moving stream, the superabsorbent material (232) and the coating material (233) pass through a zone where an effective amount of association agent (235) is applied to the superabsorbent material (232) and the coating material (233). This zone is generally located in the vicinity of a sprayer means (234) positioned near the center of the plate (227). After the association agent is applied, the inlet temperature of the upward-moving stream (229) of fluidizing gas may be elevated to a temperature in excess of room temperature. The cyclic flow of the superabsorbent material (232) and the coating material (233) is generally allowed to continue in the chamber (221) until at least a portion of the coating material comes into intimate association with the superabsorbent material to form an absorbent composite. The absorbent composite is then recovered or removed from the chamber (221). The absorbent composite so formed includes at least one particle of a superabsorbent material covered with a coating of

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hydrophilic and silicate particles. At least a portion of the coating is in intimate association with and covering the surface of the superabsorbent material.

Optionally, after formation, the absorbent composite of the present invention may remain in the fluidized bed coating apparatus and subject to the strong upward current or stream of fluidizing gas at an elevated temperature until the moisture content of the absorbent composite is less than that which would support the growth of microorganisms. While not desiring to be bound by theory, it is believed that to minimize the likelihood of the growth of microorganisms, the moisture content of the absorbent composites should be 15 percent or less by weight; desirably, 10 percent or less by weight; more desirably, 5 percent or less by weight; and most desirably, 3 percent or less by weight. Although embodiments of the process have been described herein as optionally drying a absorbent composite in the apparatus, the optional drying of a absorbent composite could be accomplished either in the apparatus or out of the apparatus according to any of a number of other drying processes known to those skilled in the art.

Various embodiments of the present process may operate at inlet temperatures ranging from about room temperature to about 72 °C. The inlet temperature may, however, range considerably higher than about 72 °C so long as the bed temperature in the apparatus does not exceed a temperature that would cause decomposition of the absorbent composite or any material included in the absorbent composite. The selection of a particular inlet temperature would depend on the superabsorbent material, the coating material and the association agent, and may be readily selected by one skilled in the art.

A fluidized bed coating process is relatively mild in its effect on the superabsorbent material and is therefore less damaging to the microstructure of the superabsorbent material as compared to other processes. Although discussed in terms of being formed in a fluidized bed coating process, the absorbent composites of the present invention may also be formed using a variety of other processes incorporating, for example, a V-shell blender or other apparatus that is relatively mild in its effect on the superabsorbent material.

## TEST METHODS

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### Free Swell Gel Bed Permeability Test

As used herein, the Free Swell Gel Bed Permeability (GBP) Test determines the permeability of a swollen bed of gel particles (e.g., such as the absorbent composites or the non-coated superabsorbent material), under what is commonly referred to as "free swell" conditions. The term "free swell" means that the gel particles are allowed to swell without a restraining load upon absorbing test solution as will be described. A suitable apparatus for conducting the Gel Bed Permeability Test is illustrated in FIGs. 2 and 3 and indicated

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generally at 28. The test apparatus (28) includes a sample container, generally indicated at 30, and a piston, generally indicated at 36. The piston (36) comprises a cylindrical LEXAN shaft (38) having a concentric cylindrical hole (40) bored down the longitudinal axis of the shaft. Both ends of the shaft (38) are machined to provide upper and lower ends respectively designated 42, 46. A weight (48) rests on one end (42) and has a cylindrical hole (48a) bored through at least a portion of its center.

A circular piston head (50) is positioned on the other end (46) and is provided with a concentric inner ring of seven holes (60), each having a diameter of about 0.95 cm, and a concentric outer ring of fourteen holes (54), also each having a diameter of about 0.95 cm. The holes (54, 60) are bored from the top to the bottom of the piston head (50). The piston head (50) also has a cylindrical hole (62) bored in the center thereof to receive an end (46) of the shaft (38). The bottom of the piston head (50) may also be covered with a biaxially stretched 100 mesh stainless steel screen (64).

The sample container (30) includes a cylinder (34) and a 400 mesh stainless steel cloth screen (66) that is biaxially stretched to tautness and attached to the lower end of the cylinder. A gel particle sample (68) is supported on the screen (66) within the cylinder (34) during testing.

The cylinder (34) may be bored from a transparent LEXAN rod or equivalent material, or it may be cut from a LEXAN tubing or equivalent material, and has an inner diameter of about 6 cm (e.g., a cross-sectional area of about 28.27 cm<sup>2</sup>), a wall thickness of about 0.5 cm and a height of approximately 10 cm. Drainage holes (not shown) are formed in the sidewall of the cylinder (34) at a height of approximately 7.8 cm above the screen (66) to allow liquid to drain from the cylinder to thereby maintain a fluid level in the sample container at approximately 7.8 cm above the screen (66). The piston head (50) is machined from a LEXAN rod or equivalent material and has a height of approximately 16 mm and a diameter sized such that it fits within the cylinder (34) with minimum wall clearance but still slides freely. The shaft (38) is machined from a LEXAN rod or equivalent material and has an outer diameter of about 2.22 cm and an inner diameter of about 0.64 cm.

The shaft upper end (42) is approximately 2.54 cm long and approximately 1.58 cm in diameter, forming an annular shoulder (47) to support the weight (48). The weight (48) has an inner diameter of about 1.59 cm so that it slips onto the upper end (42) of the shaft (38) and rests on the annular shoulder (47) formed thereon. The weight (48) can be made from stainless steel or from other suitable materials resistant to corrosion in the presence of the test solution, which is 0.9 weight percent sodium chloride solution in distilled water. The combined weight of the piston (36) and weight (48) is approximately 596 grams (g), which corresponds to a pressure applied to the sample (68) of about 0.3 pounds per square inch (psi), or about 20.7 dynes/cm<sup>2</sup> (2.07 kPa), over a sample area of about 28.27 cm<sup>2</sup>.

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When the test solution flows through the test apparatus during testing as described below, the sample container (30) generally rests on a 16 mesh rigid stainless steel support screen (not shown). Alternatively, the sample container (30) may rest on a support ring (not shown) diametrically sized substantially the same as the cylinder (34) so that the support ring does not restrict flow from the bottom of the container.

To conduct the Gel Bed Permeability Test under "free swell" conditions, the piston (36), with the weight (48) seated thereon, is placed in an empty sample container (30) and the height is measured using a suitable gauge accurate to 0.01 mm with the platen removed. It is important to measure the height of each sample container (30) empty and to keep track of which piston (36) and weight (48) is used when using multiple test apparatus. The same piston (36) and weight (48) should be used for measurement when the sample (68) is later swollen following saturation.

The sample to be tested is prepared from particles which are prescreened through a U.S. standard 20 mesh screen and retained on a U.S. standard 50 mesh screen. As a result, the test sample includes particles sized in the range of about 300 to about 850 microns. The particles can be prescreened by hand or automatically. Approximately 0.9 grams of the sample is placed in the sample container (30), and the container, without the piston (36) and weight (48) therein, is then submerged in the test solution for a time period of about 60 minutes to saturate the sample and allow the sample to swell free of any restraining load.

At the end of this period, the piston (36) and weight (48) assembly is placed on the saturated sample (68) in the sample container (30) and then the sample container (30), piston (36), weight (48), and sample (68) are removed from the solution. The thickness of the saturated sample (68) is determined by again measuring the height from the bottom of the weight (48) to the top of the cylinder (34), using the same thickness gauge used previously provided that the zero point is unchanged from the initial height measurement. The height measurement obtained from measuring the empty sample container (30), piston (36), and weight (48) is subtracted from the height measurement obtained after saturating the sample (68). The resulting value is the thickness, or height "H" of the swollen sample.

The permeability measurement is initiated by delivering a flow of the test solution into the sample container (30) with the saturated sample (68), piston (36), and weight (48) inside. The flow rate of test solution into the container is adjusted to maintain a fluid height of about 7.8 cm above the bottom of the sample container. The quantity of solution passing through the sample (68) versus time is measured gravimetrically. Data points are collected every second for at least twenty seconds once the fluid level has been stabilized to and maintained at about 7.8 cm in height. The flow rate  $Q$  through the swollen sample (68) is determined in units of grams/second (g/s) by a linear least-square fit of fluid passing through the sample (68) (in grams) versus time (in seconds).



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Permeability in  $\text{cm}^2$  is obtained by the following equation:

$$K = [Q \cdot H \cdot \mu] / [A \cdot \rho \cdot P]$$

5        where  $K$  = Permeability ( $\text{cm}^2$ ),  $Q$  = flow rate (g/sec),  $H$  = height of sample (cm),  $\mu$   
= liquid viscosity (poise) (approximately one centipoises for the test solution used with this  
Test),  $A$  = cross-sectional area for liquid flow ( $\text{cm}^2$ ),  $\rho$  = liquid density ( $\text{g/cm}^3$ )  
(approximately one  $\text{g/cm}^3$ , for the test solution used with this Test) and  $P$  = hydrostatic  
pressure ( $\text{dynes/cm}^2$ ) (normally approximately 7,652  $\text{dynes/cm}^2$ ). The hydrostatic pressure is  
10        calculated from

$$P = \rho \cdot g \cdot h$$

15        where  $\rho$  = liquid density ( $\text{g/cm}^3$ ),  $g$  = gravitational acceleration, nominally 981  
 $\text{cm/sec}^2$ , and  $h$  = fluid height, e.g., 7.8 cm for the Gel Bed Permeability Test described herein.

A minimum of three samples are tested and the results are averaged to determine the  
Gel Bed Permeability of the sample.

#### 20        Gel Bed Permeability Under Load Test

As used herein, the Gel Bed Permeability (GBP) Under Load Test, otherwise referred  
to herein as GBP at 0.3 psi, determines the permeability of a swollen bed of gel particles (e.g.,  
the superabsorbent material or the absorbent material as those terms are used herein), under  
conditions that are commonly referred to as being "under load" conditions. The term "under  
25        load" means that swelling of the particles is restrained by a load generally consistent with  
normal usage loads applied to the particles, such as sitting, walking, twisting, etc., by the  
wearer.

More particularly, the Gel Bed Permeability Under Load Test is substantially the  
same as the Free Swell Gel Bed Permeability Test set forth previously with the following  
30        exception. After approximately 0.9 grams of the sample is placed in the sample container  
(30), the piston (36) and weight (48) are placed on the sample within the sample container  
prior to the sample container (with the piston and weight therein) being submerged in the test  
solution for a time period of about 60 minutes. As a result, a 0.3 psi restraining load is  
applied to the sample as the sample becomes saturated and swells.

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**Absorbency Under Load Test**

The Absorbency Under Load (AUL) Test measures the ability of the gel particle sample (e.g., such as the absorbent composites or the non-coated superabsorbent material) to absorb a 0.9 weight percent solution of sodium chloride in distilled water at room temperature (test solution) while the material is under a 0.9 psi load. A suitable apparatus (106) for conducting the AUL Test is illustrated in FIG. 4 and includes a Demand Absorbency Tester (DAT) (100), which is similar to the Gravimetric Absorbency Test System (GATS) available from M/K Systems of Danners, Massachusetts, U.S.A., and to the system described by Lichstein at pages 129-142 of the INDA Technological Symposium Proceedings, March 1974.

The test apparatus further comprises a test stand, generally indicated at 101 (FIG. 4), having a cavity (102) formed therein and a porous plate (103) seated in the cavity and having a central porous area of about 2.54 cm diameter formed by a plurality of bores (104) extending through the plate. The cavity (102), shown in FIG. 5, has a diameter of about 3.2 cm and the porous plate (103) has a diameter of about 3.1 cm and comprises seven bores (104), each having a diameter of about 0.3 cm. One of the bores (104) is centrally located and the remaining six bores are concentrically positioned about the central bore with the spacing from the center of the central bore to the center of each adjacent bore is about one centimeter.

A sample container for containing a sample (110) to be tested comprises a cylinder (112) and a stainless steel cloth screen (114) that is biaxially stretched to tautness and attached to the lower end of the cylinder (112). The cylinder (112) may be bored from a transparent LEXAN rod or equivalent material, or it may be cut from a LEXAN tubing or equivalent material, and has an inner diameter of about one inch (about 2.54 cm). The stainless steel cloth screen (114) is suitably a 100 mesh screen.

A disc, or piston (116) is machined from a LEXAN rod, Plexiglass or equivalent material and has a diameter sized such that it fits within the cylinder (112) with minimum wall clearance but still slides freely. The height of the piston (116) is approximately 0.8 cm and the weight of the piston is suitably about 4.4 grams to provide a load over the cross-sectional area of the sample in the container of about 0.01 psi. A weight (118) is sized (e.g., having a diameter of about 2.5 cm) for seating on the piston (116) to increase the load (e.g., in addition to the weight of the piston) on the sample. For example, a weight of about 317 grams is used to provide a load (e.g., including the piston weight) of about 0.9 psi over the cross-sectional area of the sample in the container.

The cavity (102), and hence the porous plate (103), is in fluid communication with a reservoir (120) containing test solution (0.9 weight percent sodium chloride solution in distilled water at room temperature) via a suitable conduit (122). As illustrated in FIG. 4, the reservoir (120) is seated on an electrostatic balance (108).

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A sample (110) of gel particles weighing about 0.160 grams is prepared by screening the particles through a U.S. standard 20 mesh screen and retaining the particles on a U.S. standard 50 mesh screen so that the sample comprises particles in the size range of about 300 to about 850 microns. The sample is weighed on suitable weighing paper and then loaded into the sample container (with the piston (116) removed) so that the particles overlay the screen at the bottom of the container. The sample container is gently tapped to level the bed of particles in the container.

The AUL Test is initiated by placing a circular piece of GF/A glass filter paper (124) onto the porous plate (103) over the bores (104) formed therein and allowing to become saturated by test solution delivered from the reservoir (120) to the porous plate via the conduit (122). The paper (124) is suitably sized larger than the inner diameter of the cylinder (112) and smaller than the outer diameter thereof to ensure good contact while inhibiting evaporation over the bores (104). The electrostatic balance (108) is zeroed at this time. The piston (116) and weight (118) are placed on the sample within the container and the container (with the sample, piston and weight therein) is placed on the plate (103) over the saturated glass filter paper (124) to allow test solution to be taken into the sample in the container via the conduit (122), bores (104) in the plate (102) and the filter paper.

The electrostatic balance (108) is used to measure the flow of test solution to the sample over a period of about 60 minutes. The amount (in grams) of solution taken into the sample after about 60 minutes divided by the dry weight of the sample (e.g., about 0.160 grams) is the AUL value of the sample in grams of liquid per gram weight of sample.

Two checks can be made to ensure the accuracy of the measurement. First, the height the piston (116) rises above the screen (114) at the bottom of the sample container multiplied by the cross-sectional area of the piston should roughly equal the amount of solution picked up by the sample over the 60 minute period. Second, the sample container can be weighed before (e.g., while the superabsorbent material is dry) and after the test and the difference in weight should roughly equal the amount of solution picked up by the sample over the 60 minute period.

A minimum of three tests are performed and the results are averaged to determine the AUL value at 0.9 psi. The samples are tested at  $23 \pm 1$  °C at  $50 \pm 2$  percent relative humidity.

#### Centrifuge Retention Capacity Test

The Centrifuge Retention Capacity (CRC) Test measures the ability of the gel particles (e.g., such as the absorbent composites or the non-coated superabsorbent material) to retain liquid therein after being saturated and subjected to centrifugation under controlled conditions. The resultant retention capacity is stated as grams of liquid retained per gram weight of the sample (g/g). The sample to be tested is prepared from particles which are

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prescreened through a U.S. standard 20 mesh screen and retained on a U.S. standard 50 mesh screen. As a result, the sample comprises particles sized in the range of about 300 to about 850 microns. The particles can be prescreened by hand or automatically and are stored in a sealed airtight container until testing.

5        The retention capacity is measured by placing  $0.2 \pm 0.005$  grams of the prescreened sample into a water-permeable bag which will contain the sample while allowing a test solution (0.9 weight percent sodium chloride in distilled water) to be freely absorbed by the sample. A heat-sealable tea bag material, such as that available from Dexter Corporation of Windsor Locks, Connecticut, USA, as model designation 1234T heat sealable filter paper  
10       works well for most applications. The bag is formed by folding a 5-inch by 3-inch sample of the bag material in half and heat-sealing two of the open edges to form a 2.5-inch by 3-inch rectangular pouch. The heat seals should be about 0.25 inches inside the edge of the material. After the sample is placed in the pouch, the remaining open edge of the pouch is also heat-sealed. Empty bags are also made to serve as controls. Three samples (e.g., filled and sealed  
15       bags) are prepared for the test. The filled bags must be tested within three minutes of preparation unless immediately placed in a sealed container, in which case the filled bags must be tested within thirty minutes of preparation.

      The bags are placed between two TEFLON<sup>®</sup> coated fiberglass screens having 3 inch openings (Taconic Plastics, Inc., Petersburg, New York, USA) and submerged in a pan of the  
20       test solution at 23 degrees Celsius, making sure that the screens are held down until the bags are completely wetted. After wetting, the samples remain in the solution for about  $30 \pm 1$  minutes, at which time they are removed from the solution and temporarily laid on a non-absorbent flat surface. For multiple tests, the pan should be emptied and refilled with fresh test solution after 24 bags have been saturated in the pan.

25       The wet bags are then placed into the basket of a suitable centrifuge capable of subjecting the samples to a g-force of about 350. One suitable centrifuge is a Heraeus LaboFuge 400 having a water collection basket, a digital rpm gauge, and a machined drainage basket adapted to hold and drain the bag samples. Where multiple samples are centrifuged, the samples must be placed in opposing positions within the centrifuge to balance the basket  
30       when spinning. The bags (including the wet, empty bags) are centrifuged at about 1,600 rpm (e.g., to achieve a target g-force of about 350), for 3 minutes. The bags are removed and weighed, with the empty bags (controls) being weighed first, followed by the bags containing the samples. The amount of solution retained by the sample, taking into account the solution retained by the bag itself, is the CRC of the sample, expressed as grams of fluid per gram of  
35       sample. More particularly, the CRC is determined as:

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$$\text{CRC} = (\text{SB} - \text{EB} - \text{DS})/\text{DS}$$

where: SB = sample/bag weight after centrifuge;

EB = empty bag weight after centrifuge; and

DS = dry sample weight

The three samples are tested and the results are averaged to determine the CRC. The samples are tested at  $23 \pm 1$  °C at  $50 \pm 2$  percent relative humidity.

### EXAMPLES

The following Examples describe various versions of the invention. Other versions within the scope of the claims herein will be apparent to one skilled in the art from consideration of the specification or practice of the invention as disclosed herein. It is intended that the specification, together with the Examples, be considered exemplary only, with the scope and spirit of the invention being indicated by the claims which follow the Examples.

#### Example 1

This Example serves to demonstrate the significant improvement in GBP exhibited by an absorbent composite compared to the GBP of a corresponding non-coated superabsorbent material. The superabsorbent utilized in this Example was Favor SXM 9543, a polyacrylate superabsorbent material commercially available from Stockhausen, Inc., Greensboro, North Carolina, USA. The coating included Zeofree 5175A, a granulated, precipitated silica commercially available from J.M. Huber, Havre de Grace, Maryland, USA, and Ex-cel 110, a cellulose powder commercially available from Functional Foods, Elizabethtown, New Jersey, USA. The absorbent composite of this Example, Favor SXM 9543 covered with a coating of Zeofree 5175A and Ex-cel 110 particles, was prepared at The Coating Place, Verona, Wisconsin, USA, using an embodiment of the process described herein. The association agent utilized was distilled water. The mixture of Favor SXM 9543, Zeofree 5175A and the Ex-cel 110 was added to the fluidized bed coating apparatus. While the mixture was being fluidized at 70 °F at 35 standard cubic feet per minute air flow, the association agent was added to the process via a spray nozzle at a rate of 0.5 ml/s. In this instance, the association agent utilized was distilled water. The superabsorbent material, the coating materials and the association agent were added in the amounts indicated in Table I. After the association agent was added, the fluidized bed coating apparatus was operated for 5 minutes with an inlet air temperature of 70 °F after which the absorbent composite was collected. Testing was done after sieving the absorbent composite to remove particles less than 300 microns.

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Table I

Code	Superabsorbent Material (g)	Association Agent (g)	Ex-cel 110 (g)	Zeofree 5175A (g)	Non- Coated Free Swell GBP (x 10 <sup>-3</sup> cm <sup>2</sup> )	Coated Free Swell GBP (x 10 <sup>-3</sup> cm <sup>2</sup> )
20909A12	285.5	56	71	88	32	132

The Free Swell GBP exhibited by the foregoing absorbent composite is at least 300 % greater than the Free Swell GBP exhibited by the corresponding non-coated superabsorbent material.

Example 2

This Example serves to illustrate the increase of GBP with another superabsorbent and a different composition of coating materials. The superabsorbent utilized in this Example was Favor SXM 880, a polyacrylate superabsorbent material commercially available from Stockhausen, Inc., Greensboro, North Carolina, USA. The coating included Zeofree 5175A, a granulated, precipitated silica commercially available from J.M. Huber, Havre de Grace, Maryland, USA, and Ex-cel 110, a cellulose powder commercially available from Functional Foods, Elizabethtown, New Jersey, USA. The absorbent composite of this Example, Favor SXM 880 covered with a coating of Zeofree 5175A and Ex-cel 110 particles, was prepared at The Coating Place, Verona, Wisconsin, USA, using an embodiment of the process described herein. The association agent utilized was distilled water. The mixture of Favor SXM 880, Zeofree 5175A and the Ex-cel 110 was added to the fluidized bed coating apparatus. While the mixture was being fluidized at 70 °F at 25 standard cubic feet per minute air flow, the association agent was added to the process via a spray nozzle at a rate of 0.5 ml/s. In this instance, the association agent utilized was distilled water. The superabsorbent material, the coating materials and the association agent were added in the amounts indicated in Table II. After the association agent were added, the fluidized bed coating apparatus was operated for 5 minutes with an inlet air temperature of 70 °F after which the absorbent composite was collected. Testing was done after sieving the absorbent composite to remove particles less than 300 microns.

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Table II

Code	Superabsorbent Material (g)	Association Agent (g)	Ex-cel 110 (g)	Zeofree 5175A (g)	Non- Coated Free Swell GBP ( $\times 10^{-8}$ cm <sup>2</sup> )	Coated Free Swell GBP ( $\times 10^{-8}$ cm <sup>2</sup> )
20910A16	285.5	54	17	144	8	47

The Free Swell GBP exhibited by the foregoing absorbent composite is at least 450 % greater than the Free Swell GBP exhibited by the corresponding non-coated superabsorbent material.

Example 3

This Example serves to illustrate the increase of GBP with another superabsorbent material. The superabsorbent utilized in this Example was Dow XUS 40703.02, a polyacrylate superabsorbent material commercially available from Dow Chemical Company, Midland, Michigan, USA. The coating included Zeofree 5175A, a granulated, precipitated silica commercially available from J.M. Huber, Havre de Grace, Maryland, USA, and Ex-cel 110, a cellulose powder commercially available from Functional Foods, Elizabethtown, New Jersey, USA. The absorbent composite of this Example, XUS 40703.02 covered with a coating of Zeofree 5175A and Ex-cel 110 particles, was prepared at The Coating Place, Verona, Wisconsin, USA, using an embodiment of the process described herein. The association agent utilized was distilled water. The mixture of XUS 40703.02, Zeofree 5175A and the Ex-cel 110 was added to the fluidized bed coating apparatus. While the mixture was being fluidized at 70 °F at 25 standard cubic feet per minute air flow, the association agent was added to the process via a spray nozzle at a rate of 0.5 ml/s. In this instance, the association agent utilized was distilled water. The superabsorbent material, the coating materials and the association agent were added in the amounts indicated in Table II. After the association agent were added, the fluidized bed coating apparatus was operated for 5 minutes with an inlet air temperature of 70 °F after which the absorbent composite was collected. Testing was done after sieving the absorbent composite to remove particles less than 300 microns.

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Table III

Code	Superabsorbent Material (g)	Association Agent (g)	Ex-cel 110 (g)	Zeofree 5175A (g)	Non- Coated Free Swell GBP (x 10 <sup>-4</sup> cm <sup>2</sup> )	Coated Free Swell GBP (x 10 <sup>-4</sup> cm <sup>2</sup> )
20910A20	285.5	56	71	88	37	60

The Free Swell GBP exhibited by the foregoing absorbent composite is at least 60 % greater than the Free Swell GBP exhibited by the corresponding non-coated superabsorbent material.

**Example 4**

This Example serves to demonstrate the significant improvement in GBP under load exhibited by an absorbent composite compared to the GBP under load of a corresponding non-coated superabsorbent material. The superabsorbent utilized in this Example was Favor SXM 9543, a polyacrylate superabsorbent material commercially available from Stockhausen, Inc., Greensboro, North Carolina, USA. The coating included Zeofree 5175A, a granulated, precipitated silica commercially available from J.M. Huber, Havre de Grace, Maryland, USA, and Ex-cel 110, a cellulose powder commercially available from Functional Foods, Elizabethtown, New Jersey, USA. The absorbent composite of this Example, Favor SXM 9543 covered with a coating of Zeofree 5175A and Ex-cel 110 particles, was prepared at The Coating Place, Verona, Wisconsin, USA, using an embodiment of the process described herein. The association agent utilized was distilled water. The mixture of Favor SXM 9543, Zeofree 5175A and the Ex-cel 110 was added to the fluidized bed coating apparatus. While the mixture was being fluidized at 70 °F at 27.5 standard cubic feet per minute air flow, the association agent was added to the process via a spray nozzle at a rate of 0.5 ml/s. The superabsorbent material, the coating materials and the association agent were added in the amounts indicated in Table IV. After the association agent was added, the fluidized bed coating apparatus was operated for 5 minutes with an inlet air temperature of 70 °F after which the absorbent composite was collected. Testing was done after sieving the absorbent composite to remove particles less than 300 microns.



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Table IV

Code	Superabsorbent Material (g)	Association Agent (g)	Ex-cel 110 (g)	Zeofree 5175A (g)	Non-Coated Free Swell GBP ( $\times 10^{-3} \text{ cm}^3$ )	Coated Free Swell GBP ( $\times 10^{-3} \text{ cm}^3$ )
30113A16	583	92	41	51	32	74

The Free Swell GBP exhibited by the foregoing absorbent composite is at least 130 % greater than the Free Swell GBP exhibited by the corresponding non-coated superabsorbent material.

The materials of this Example also demonstrated A GBP Under Load of at least  $25 \times 10^{-8} \text{ cm}^2$ , which is at least 90 % greater than the GBP Under Load exhibited by the corresponding non-coated superabsorbent material.

Table V

Code	CRC (g/g)	Non-Coated GBP Under Load ( $\times 10^{-8} \text{ cm}^2$ )	Coated GBP Under Load ( $\times 10^{-8} \text{ cm}^2$ )
30113A16	20	13	25

**Example 5**

This Example serves to demonstrate the significant improvement in GBP under load exhibited by an absorbent composite compared to the GBP under load of a corresponding non-coated superabsorbent material. The superabsorbent utilized in this Example was Favor SXM 9543, a polyacrylate superabsorbent material commercially available from Stockhausen, Inc., Greensboro, North Carolina, USA. The coating included a smaller particle size cut of Zeofree 5175A, a granulated, precipitated silica commercially available from J.M. Huber, Havre de Grace, Maryland, USA, and Ex-cel 110, a cellulose powder commercially available from Functional Foods, Elizabethtown, New Jersey, USA. The smaller particle size material had a mass median diameter of about 210 microns (compared to a mass median diameter of about 340 microns for the other Examples discussed herein). The absorbent composite of this Example, Favor SXM 9543 covered with a coating of Zeofree 5175A and Ex-cel 110

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particles, was prepared at The Coating Place, Verona, Wisconsin, USA, using an embodiment of the process described herein. The association agent utilized was distilled water. The mixture of Favor SXM 9543, Zeofree 5175A and the Ex-cel 110 was added to the fluidized bed coating apparatus. While the mixture was being fluidized at 70 °F at 28 standard cubic feet per minute air flow, the association agent was added to the process via a spray nozzle at a rate of 0.5 ml/s. The superabsorbent material, the coating materials and the association agent were added in the amounts indicated in Table VI. After the association agent was added, the fluidized bed coating apparatus was operated for 5 minutes with an inlet air temperature of 72 °F after which the absorbent composite was collected. Testing was done after sieving the absorbent composite to remove particles less than 300 microns.

Table VI

Code	Superabsorbent Material (g)	Association Agent (g)	Ex-cel 110 (g)	Zeofree 5175A (g)	Non-Coated Free Swell GBP ( $\times 10^{-8} \text{ cm}^2$ )	Coated Free Swell GBP ( $\times 10^{-8} \text{ cm}^2$ )
30114A2	375	60	27	33	32	83

The Free Swell GBP exhibited by the foregoing absorbent composite is at least 160 % greater than the Free Swell GBP exhibited by the corresponding non-coated superabsorbent material.

The materials of this Example also demonstrated A GBP Under Load of at least  $21 \times 10^{-8} \text{ cm}^2$ , which is at least 60 % greater than the GBP Under Load exhibited by the corresponding non-coated superabsorbent material.

Table VII

Code	CRC (g/g)	Non-Coated GBP Under Load ( $\times 10^{-8} \text{ cm}^2$ )	Coated GBP Under Load ( $\times 10^{-8} \text{ cm}^2$ )
30114A2	22	13	21

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The data in Table VIII is illustrative of AUL and CRC values of the Codes of foregoing Examples numbered 1, 2, and 3.

Table VIII

Code	AUL at 0.01 psi (g/g)	AUL at 0.3 psi (g/g)	AUL at 0.6 psi (g/g)	AUL at 0.9 psi (g/g)	CRC (g/g)
20909A12	34.8	22.0	18.5	15.6	19.5
20910A16	37.8	21.4	18.0	14.9	23.2
20910A20	37.8	21.6	18.1	14.5	21.4

5

#### Example 6

This Example serves to illustrate the increase of GBP with another superabsorbent material. The superabsorbent utilized in this Example was Dow XUS 40703.02, a polyacrylate superabsorbent material commercially available from Dow Chemical Company, Midland, Michigan, USA. The coating included Zeofree 5175A, a granulated, precipitated silica commercially available from J.M. Huber, Havre de Grace, Maryland, USA, and Ex-cel 110, a cellulose powder commercially available from Functional Foods, Elizabethtown, New Jersey, USA. The absorbent composite of this Example, XUS 40703.02 covered with a coating of Zeofree 5175A and Ex-cel 110 particles, was prepared at The Coating Place, Verona, Wisconsin, USA, using an embodiment of the process described herein. The association agent utilized was distilled water. The mixture of XUS 40703.02, Zeofree 5175A and the Ex-cel 110 was added to the fluidized bed coating apparatus. While the mixture was being fluidized at 70 °F at 25 standard cubic feet per minute air flow, the association agent was added to the process via a spray nozzle at a rate of 0.5 ml/s. In this instance, the association agent utilized was distilled water. The superabsorbent material, the coating materials and the association agent were added in the amounts indicated in Table III. After the association agent were added, the fluidized bed coating apparatus was operated for 5 minutes with an inlet air temperature of 70 °F after which the absorbent composite was collected. Testing was done after sieving the absorbent composite to remove particles less than 300 microns.

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Table IX

Code	Superabsorbent Material (g)	Association Agent (g)	Ex-cel 110 (g)	Zeofree 5175A (g)	Non- Coated Free Swell GBP (x 10 <sup>-3</sup> cm <sup>3</sup> )	Coated Free Swell GBP (x 10 <sup>-3</sup> cm <sup>3</sup> )
20910A18	285.5	43	144	28	37	44

5 The Free Swell GBP exhibited by the foregoing absorbent composite is at least 20 % greater than the Free Swell GBP exhibited by the corresponding non-coated superabsorbent material. The CRC of the foregoing Code was 24.4 g/g.

10 Having described the invention in rather full detail, it will be readily apparent that various changes and modifications can be made without departing from the spirit of the invention. All of such changes and modifications are contemplated as being within the scope of the invention as defined by the appended claims and any equivalents thereto.